R·I·T Rochester Institute of Technology

MCSL
MUNSELL COLOR SCIENCE LAB

2010 Annual Report

Chester F. Carlson CENTER for IMAGING SCIENCE
Creating and sharing knowledge, expanding human perception

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Munsell Color Science Laboratory

Front Row: Dave Wyble, Jonathan Phillipps, Alicia Stillwell, Rachael Henderson, Lin Chen, Jie Feng, Yiheng Cai. **Middle Row:** Adria Fores Herranz, Val Hemink, Jen Krjschwitz, Susan Farnand, Chris Jiang, Roy Berns, Rod Heckaman. **Back Row:** Franziska Frey, Farhad Abed, Mark Fairchild, Ben Darling, Hao Li, Jinwei Gu, Lawrence Taplin, Jim Ferwerda, Brian Gamm, Tongbo Chen.

The Munsell Color Science Laboratory (MCSL) was founded at the Rochester Institute of Technology (RIT) in 1983 through a gift from the Munsell Color Foundation, Inc. The laboratory is part of the Chester F. Carlson Center for Imaging Science in RIT's College of Science. It was created, and continues to operate, with the vision of being the preeminent academic laboratory dedicated to color science education and research and the preferred source of educated color scientists for industry, academia, and government.

The following four objectives guide MCSL faculty, staff, and students in their endeavors to fulfill its vision and mission:

1) To provide undergraduate and graduate education in color science,
2) To carry on applied and fundamental research,
3) To facilitate spectral, colorimetric, photometric, spatial, and geometric measurements at the state of the art, and
4) To sustain an essential ingredient for the success of the first three — namely, liaison with industry, academia, and government.

The mission of the Munsell Color Science Laboratory is to advance the science, understanding, and technology of color and appearance through education, research, and outreach.

Munsell Color Science Laboratory Supporters

The following lists those that have contributed to our research and education programs through grants, contracts, and gifts during 2010. Thank you for your support and generosity!

Avian Rochester
Avian Technologies LLC
Dolby Laboratories
eeColor
Entertainment Experience LLC
Scot Fernandez (with match from Hallmark Cards Inc.)
Getty Conservation Institute
Illford
Andy and Maureen Juenger
The Andrew W. Mellon Foundation
National Science Foundation (NSF)
Onyx Graphics
Sherwin-Williams
X-Rite Inc.
Huan Zeng (with match from the Hewlett Packard Company)

Endowments and Long-Term Commitments:

Munsell Color Science Laboratory
Richard S. Hunter Professorship
Macbeth-Engel Fellowship
Franc Grum Memorial Scholarship
Max Saltzman Memorial Scholarship

Director's Note

2010 marked the beginning of our second quarter century! Following this milestone, we have begun to plan our future, particularly with respect to our research agenda. Looking back, our most funded area of research has been color imaging, spanning colorimetric characterization of input, display, and output devices; color and image appearance modeling; and novel devices such as spectral cameras and HDR displays. The research frontiers were numerous and our worldwide sponsors sought answers to questions with direct applicability to their varied products. Today, these questions are largely answered and we are proud to have contributed to the evolution of color and imaging becoming synonymous in consumer and professional electronics.

Concomitantly, we have created a center of excellence for traditional color science with contributions to precision and accuracy in spectrophotometry, observer metamerism and color-matching functions, and color-differences. A topic that was contained within our curricula but seldom explored in research was material appearance such as specular gloss, distinctness-of-image gloss, and similar surface phenomena. A natural extension to our imaging and traditional color science research is to study color and material appearance as a single Gestalt. This exploration will become one of our research backbones as we move forward. Indeed, we have already made considerable progress. Jim Ferwerda's research continues to thrive with a new grant from the National Science Foundation. Beginning September 2010, Dr. Jinwei Gu joined MCSL as an assistant professor in imaging science. Jinwei completed his Ph.D. in computational photography at Columbia University under the direction of Shree Nayar. Jinwei and I are collaborating on using computational photography as a method of simulating varnish removal of Van Gogh paintings. MCSL now has two linear light stages that can measure bidirectional reflectance distribution functions and surface normals simultaneously for "flat" objects.

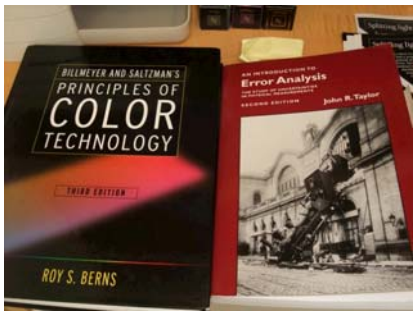
A second area of expansion is museum imaging. Dr. Franziska Frey, the McGhee Professor at the RIT School of Print Media, also joined MCSL during the fall. Her research interests include digital asset management and establishing guidelines for viewing, capturing, quality control, and archiving digital images. Her research well complements my own research in improving the color accuracy of museum imaging and printing. Joining Franziska is Susan Farnand, assistant scientist and part-time doctoral student in Color Science.

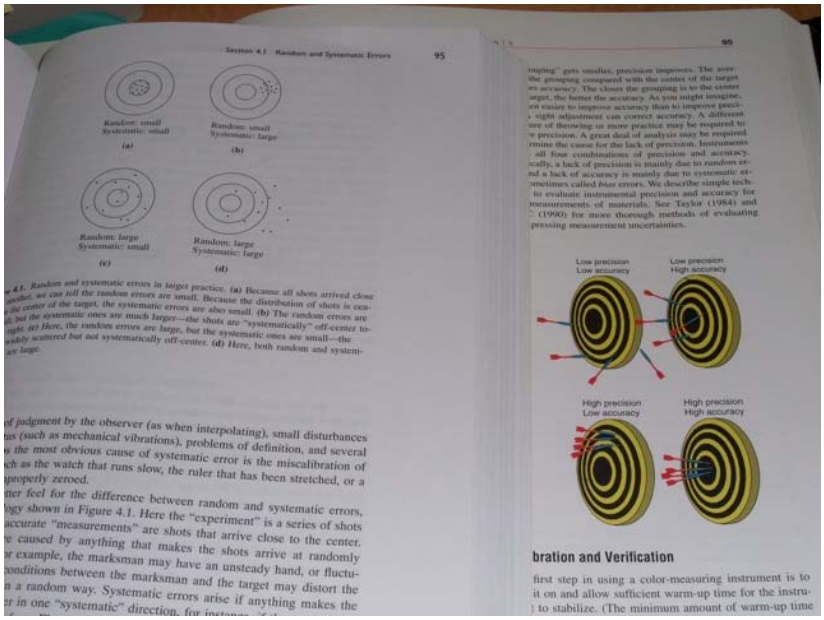
September also marked a change in Mark Fairchild's responsibilities as he became Associate Dean for Research and Graduate Education within the College of Science. Mark will divide his time between administration, teaching, and scholarship.

I invite you to read our annual report where you can find a summary of our activities and accomplishments during 2010. As always, our education and research programs would not be nearly as effective without the support of our sponsors, RIT, and our friends, worldwide. Thank you so much!

Roy S. Berns
Richard S. Hunter Professor in Color Science, Appearance, and Technology
Director, Munsell Color Science Laboratory
March 2011

P.S.
From January through May, 2010, I was a Visiting Scholar at the Getty Conservation Institute in Los Angeles. Senior Scientist Jim Druzik and I had a number of interesting discussions about error propagation in spectrophotometry. Jim found an incredible coincidence on page 95 of these books, of which the statistical probability of occurrence is difficult to calculate, but not that my version is more colorful!





Industrial Education

MCSL Visiting Scientist Program

For nearly two decades, MCSL has been hosting industrial scientists and engineers for extended periods. These visiting scientists spend 1-2 years in residence at MCSL and work on fundamental research problems of interest to their employer and MCSL researchers. They also have time to participate in formal MCSL course offerings if they so desire and to experience the culture and climate of Rochester and the entire United States. Feel free to contact any member of the MCSL faculty or staff for more information on becoming an MCSL visiting scientist.

During 2010, we hosted two visiting scientists: Yiheng Cai from Beijing University of Technology and Jie Feng from Yunnan Normal University.

MCSL Summer Short Courses

Every June, MCSL presents this course for people interested in color measurement, specification, control, reproduction, or use. The lectures are designed to form a coherent course that introduces the fundamental concepts of color science, describes various applications, and introduces cutting-edge research areas in color science.

Details can be found on our web page or call +1-585-475-7189.

Last year, we presented "The Essentials of Color Science" with the following lectures:

Introduction and Overview of Color Science
Color Perception and Illumination
Fundamentals of Vision for Color Science
CIE Colorimetry: Tristimulus Values and Chromaticities
CIELAB, ΔE*ab, and One-Dimensional Scales
Measuring the Spectral Properties of Materials
Measuring Material Appearance
Color Difference Formulas and Setting Color Tolerances
Instrumental-Based Color Matching
Advances in Color Science: An Overview

For June 2011, we have restructured our summer short course into a two-day course, "The Essentials of Color Science," followed by two concurrent one-day courses, "Advanced Topics in Color and Imaging," and "Instrumental-Based Color Matching."

Graduate Education in Color Science

RIT offers the only M.S. and Ph.D. programs in Color Science in the country. Imaging Science students can also concentrate in color imaging and perform research in MCSL. Worldwide, more than 100 MCSL alumni are working diligently to advance the field. Many of them are recognized leaders making significant contributions to the advancement of color science and technology. Color Science graduates are in high demand and have accepted industrial and academic positions in a variety of areas including basic and applied research, digital imaging and cinema, color instrumentation, and material appearance.

Students complete their degrees through programs in the Chester F. Carlson Center for Imaging Science within RIT's College of Science. These include the M.S. and Ph.D. programs in Color Science and Imaging Science. In addition, undergraduate students in Imaging Science and other programs occasionally complete research projects or obtain other work experience in the field of color science.

Professor Mark D. Fairchild is the Graduate Coordinator for the Color Science programs. Feel free to contact him at mdf@cis.rit.edu and see cis.rit.edu/mcsl or cis.rit.edu for more information on our academic opportunities.

"Team Mars" developing a paint calibration and verification dataset for Kubelka-Munk and spectral color reproduction experiments in the course, Color Modeling.
Left to Right: Simon Muehlemann, Adria Fores Herranz, Farhad Abed.

Current Students, Visiting Scientists, and Alumni

Key:
BS: Bachelor of Science
CS: Color Science
IE: Industrial Engineering
EE: Electrical Engineering
IPT: Imaging and Photo Technology
IS: Imaging Science
MS: Master of Science
PhD: Doctor of Philosophy

MCSL Current Students
Farhad Abed, PhD, CS
Justin Ashbaugh, MS, CS
Farouk Bonilla, PhD, IS
Lin Chen, MS, CS
Ping-Hsu (Jones) Chen, MS, CS
Benjamin Darling, PhD, CS
Maxim Derhak, PhD, CS
Susan Farnand, PhD, CS
Adriá Fores Herranz, PhD, CS
Brian Gamm, MS, CS
John Grim, MS, CS
Marissa Haddock, MS, CS
Rachel Henderson, PhD, CS
Carrie Houston, BS, IS
Jun (Chris) Jiang, PhD, CS
Hao Li, MS, CS
David Long, PhD, CS
Chris Mondiek, BS, EE
Jonathan Phillips, PhD, CS
Nannette Salvaggio, MS, CS
Alicia Stillwell, MS, CS
Joel Witwer, BS, IS
Dan Zhang, MS, CS

Visiting Scientists
Yiheng Cai, Beijing University of Technology
Jie Feng, Yunnan Normal University

Alumni
2010
Bingxin Hou, MS, IS
Suparna Kalghatgi, MS, IE

2009
Erin Fredericks, MS, IS
Rodney Heckaman, PhD, IS
Mahnaz Mohammadi, PhD, IS
Shizhe Shen, MS, CS

2008
Stacey Casella, MS, CS
Ying Chen, MS, CS
Mahdi Nezamabadi, PhD, IS
Abhijit Sarkar, MS, CS
Yang Xue, MS, IS
Hongqin (Cathy) Zhang, PhD, IS
Yonghui (Iris) Zhao, PhD, IS

2007
Kenneth Fleisher, MS, CS
Jiangtao (Willy) Kuang, PhD, IS

2006
Yongda Chen, PhD, IS
Timothy Hattenberger, MS, IS
Zhaojian (Li) Li, MS, CS
Joseph Stellbrink, MS, CS

2005
Maxim Derhak, MS, IS
Randall Guay, MS, IS
Jim Hewitt, MS, IS
Justin Laird, MS, CS
Erin Murphy Smoyer, MS, CS
Yoshio Okumara, MS, CS
Michael Surgeary, MS, IS

Alumni

2004
Rohit Patil, MS, CS
Sung Ho Park, MS, CS
Xiaoyan (Yan) Song, MS, CS

2003
D. Collin Day, MS, CS
Ellen Day, MS, CS
Scot Fernandez, MS, IS
Edward Hattenberger, MS, CS
Steve Jacob, MS, IS
Xiaoyun (Willie) Jiang, PhD, IS
Garrett Johnson, PhD, IS
David Robinson, MS, IS
Mitchell Rosen, PhD, IS
Deniz Schildkraut, MS, CS
Qun (Sam) Sun, PhD, IS

2002
Arturo Aguirre, MS, CS
Jason Babcock, MS, CS
Anthony Calabria, MS, CS
Jen Cerniglia Stanek, MS, IS
Scot Fernandez, MS, CS
Jason Gibson, MS, CS
Shuxue Quan, PhD, IS
Yat-ming Wong, MS, IS

2001
Alexei Krasnoselsky, MS, CS
Sun Ju Park, MS, CS
Michael Sanchez, MS, IS
Lawrence Taplin, MS, CS
Barbara Ulreich, MS, IS

2000
Sergio Gonzalez, MS, CS
Sharon Henley, MS, CS
Patrick Igoe, MS, IS
Susan Lubecki, MS, CS
Richard Soursa, MS, CS

1999
Gus Braun, PhD, IS
Barbara Grady, MS, CS
Katherine Loj, MS, CS
Jonathan Phillips, MS, CS
Mark Reiman, MS, CS
Mark Shaw, MS, CS
Di-Yuan Tzeng, PhD, IS
Joan Zanghi, MS, CS

1998
Scott Bennett, MS, CS
Fritz Ebner, PhD, IS
Garrett Johsnon, MS, CS
Naoya Katoh, MS, CS
David Wyble, MS, CS

1997
Peter Burns, PhD, IS
Christopher Hauf, MS, CS
Brian Hawkins, MS, CS
Jack Rahill, MS, IS
Alex Vaysman, MS, IS

1996
Karen Braun, PhD, IS
Cathy Daniels, MS, CS
Yue Qiao, MS, IS
Hae Kyung Shin, MS, IS

1995
Richard Alfvin, MS, CS
Seth Ansell, MS, CS
Susan Farnand, MS, IS

1994
Taek Kim, MS, IS
Audrey Lester, MS, CS
Jason Peterson, MS, IS
Debra Seitz Vent, MS, IS
James Shyu, MS, CS

1993
Nathan Moroney, MS, CS
Elizabeth Pirrotta, MS, CS
Mitchell Rosen, MS, IS

Alumni

1992
Mark Gorzynski, MS, IS
Rich Riffel, MS, IS
Brian Rose, MS, CS

1991
Yan Liu, MS, CS
Ricardo Motta, MS, IS
Amy North, MS, CS
Greg Snyder, MS, IS
Michael Stokes, MS, CS

1989
Mitch Miller, MS, IS
Kelvin Peterson, MS, IS
Lisa Reniff, MS, CS

1987
Denis Daoust, MS, IS
Wayne Farrell, MS, IS

1986
Mark Fairchild, MS, IS

Marissa Haddock at the 2010 RIT graduation ceremonies.

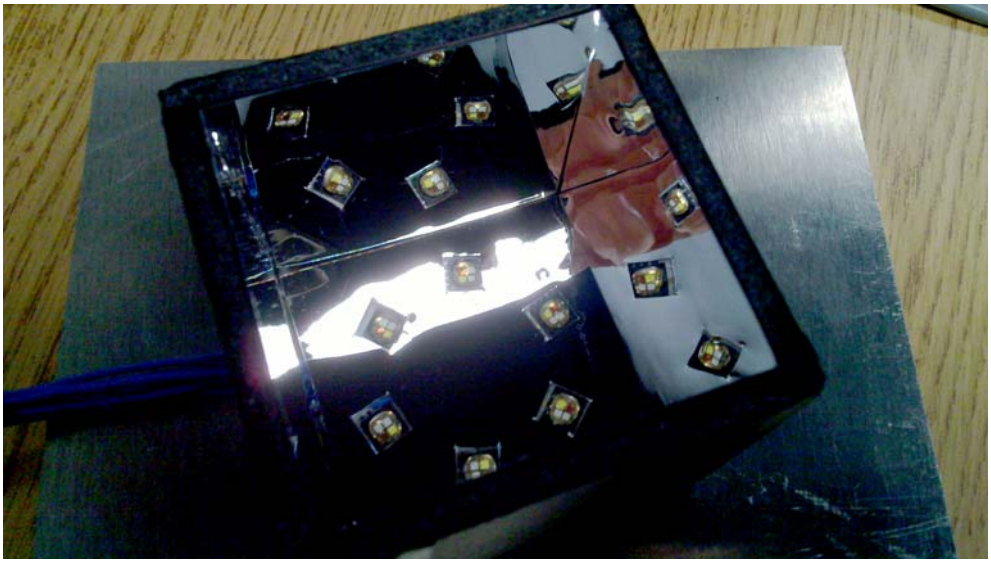
Current Research

Research in MCSL can be organized into these general themes:

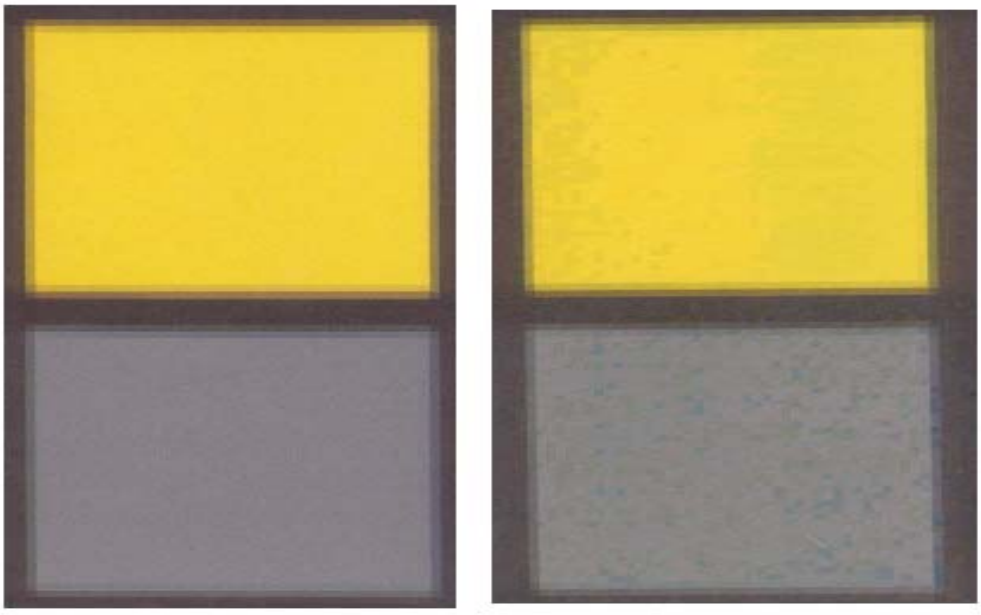
1) Colorimetry including metrology, psychophysics, and tolerance formulae modeling,
2) Image color-appearance psychophysics and modeling,
3) High-dynamic range image capture and display,
4) 3-D imaging of paintings including BRDF, surface-normal, and visible-spectral measurements and realistic image synthesis,
5) Spectral color reproduction including multi-spectral capture, multi-ink inkjet printing, and spectral color management,
6) Art conservation science,
7) Museum imaging,
8) Material appearance,
9) Computational photography.

The following is a pictorial representation of some of our research. See the Publications section for a complete listing of our scholarship during 2010.

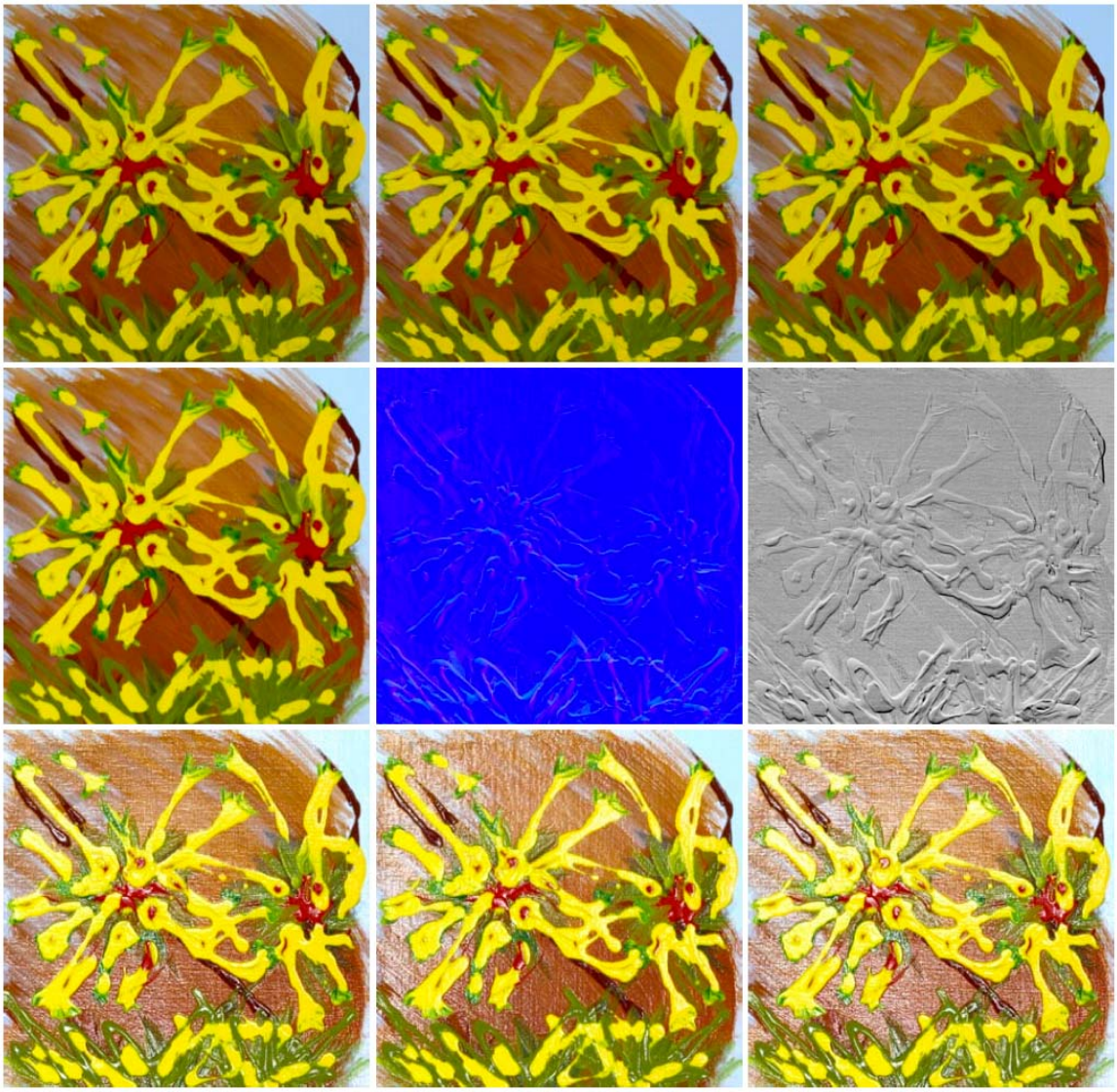
Square root and iCAM06 based image splitting for high dynamic range (HDR) displays. In this research M.S. student Dan Zhang, under the direction of Professor James Ferwerda, is developing new image appearance model based algorithms for accurately rendering HDR images on dual plane HDR display systems. Note the increased colorfulness and contrast of the HDR image split using the new iCAM06-based algorithm with respect to the standard square-root algorithm.



An early version of an experimental LCD backlight unit. This integrating box consists of an array of six high-intensity LEDs in a highly reflective enclosure. This research is being carried out by Color Science M.S. student Hao Li under the direction of Professor Mark Fairchild and explores tradeoffs between LED backlight configuration, colorfulness, and luminance in the design of display primaries for high-performance LCD displays.

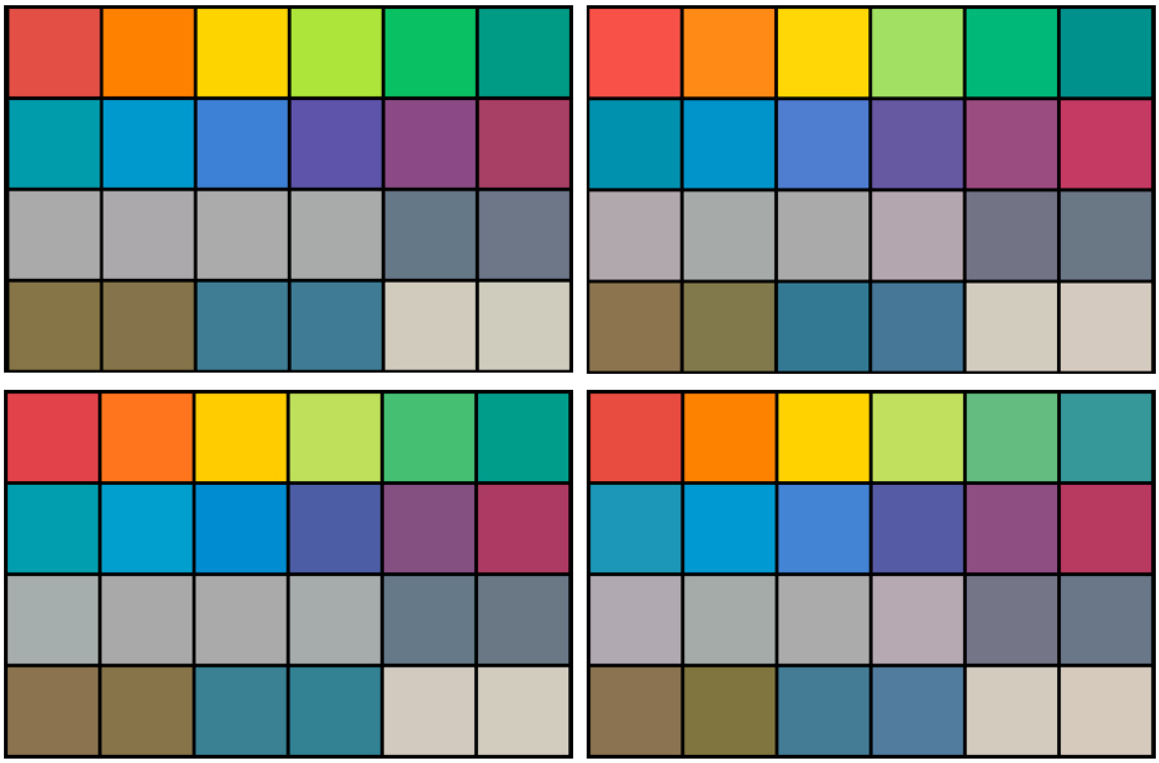


Two methods of multi-ink color separation algorithms developed in MCSL for spectral color reproduction were compared for colorimetric, spectral, image quality, and processing time. When comparing image noise, the LabPQR algorithm (left) was superior to spectral gamut mapping algorithm (right). This research was performed by Color Science Ph.D. student Maxim Derhax under the direction of Professor Roy Berns.



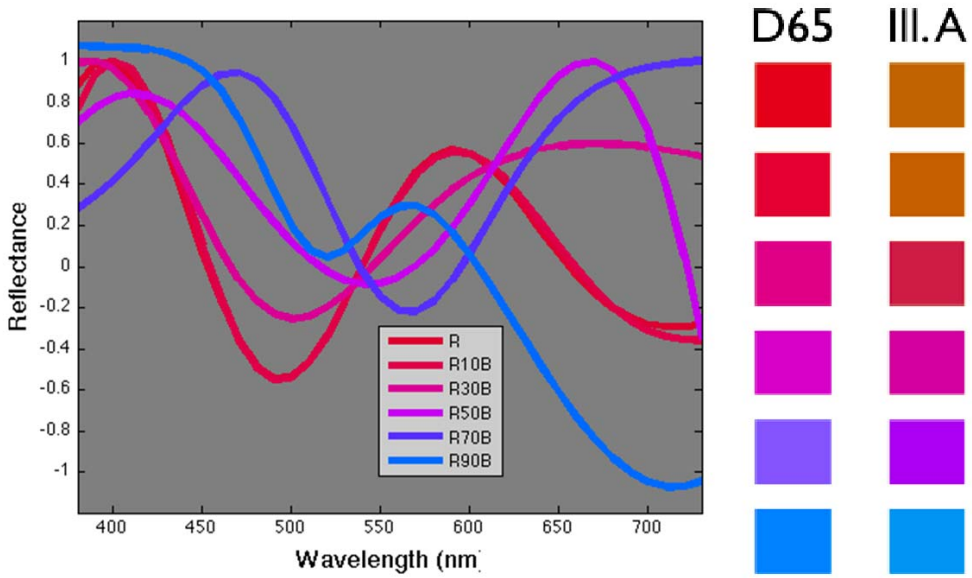
Results of polarization-enhanced three-light photometric stereo spectral imaging of cultural heritage, research sponsored by the Andrew W. Mellon Foundation and performed by Tongo Chen, Postdoctoral Fellow, under the direction of Professor Roy Berns. Row 1: the three input images taken under different illumination conditions; Row 2 from left to right: the recovered diffuse albedo, surface normal (RGB coded) and rendered surface normal; Row 3: rendered images with user defined specular albedo and roughness.

The print (left) and display and viewing (right) setups for experiments investigating the impact of workflow on perceived reproduction quality of fine art images. Research under the direction of Professor Franziska Frey.

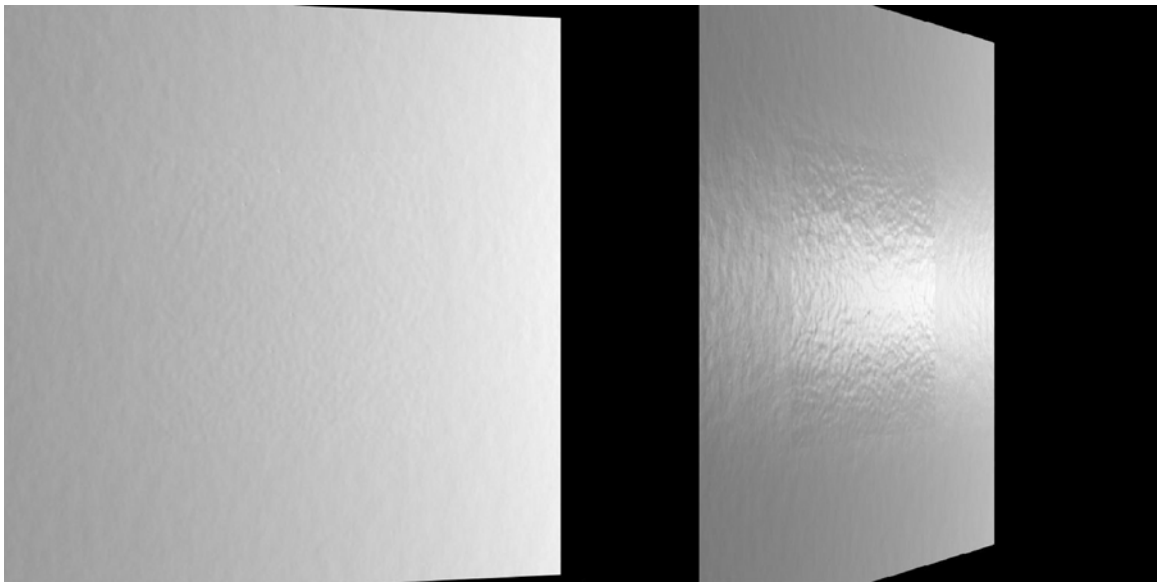


A new target to evaluate museum lighting and camera systems is under development. The research involves Color Science M.S. student Marissa Haddock under the direction of Professor Roy Berns. The target, still computational, is rendered under illuminant D65 (top left) and illuminant A (top right) for the 1931 standard observer with chromatic adaptation. Color accuracy degrades when a five-channel (bottom left) or a RGB (bottom right) camera is used and rendered under D65.

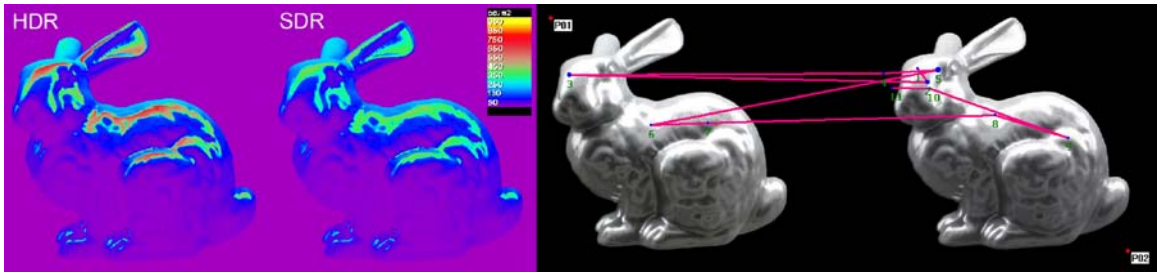
The medium and the message: Left) high quality image of a glossy black car. Right) halftoned, printed, and rescanned version of the same image. While the rightmost image is of lower "quality", its ability to represent important scene properties such as the shape and finish of the car is largely unimpaired. In this research, sponsored by the National Science Foundation, Professor James Ferwerda is developing new models of image quality that distinguish between the properties of an imaging medium and the messages it can carry.



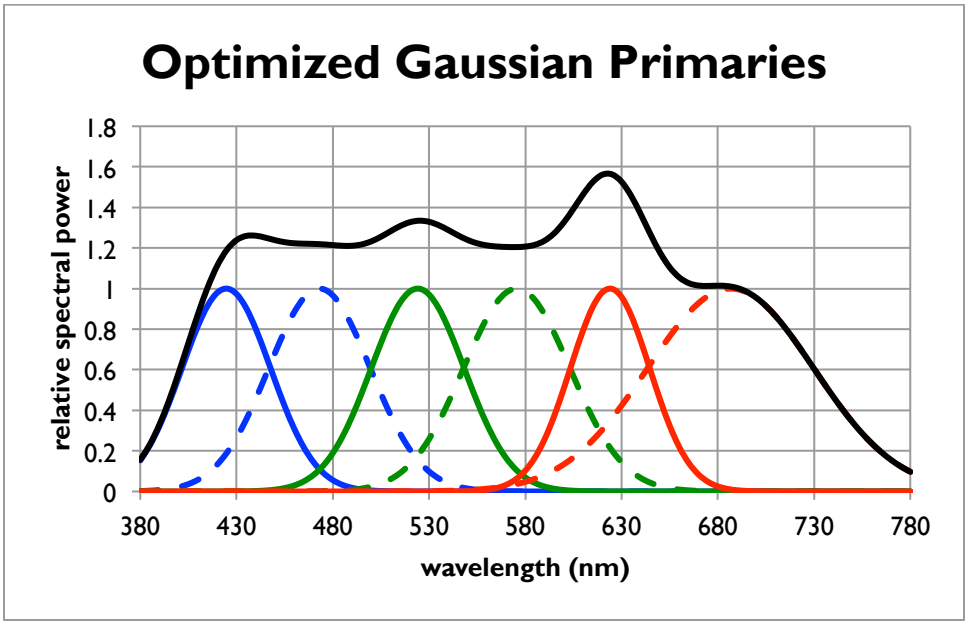
Postdoctoral Fellow Rodney Heckaman and Professor Roy Berns derived a set of spectra corresponding to Natural Color System stimuli of zero gray content, stimuli having maximum chroma while appearing as surface colors. These were derived for 24 NCS hues and the spectra were optimized to maximize color inconstancy. Six spectra are shown (left) and their rendering under illuminants D65 and A with chromatic adaptation (right). Such spectra can be used to evaluate camera-encoding errors caused by limitations in spectral sensitivity and new solid-state lighting.



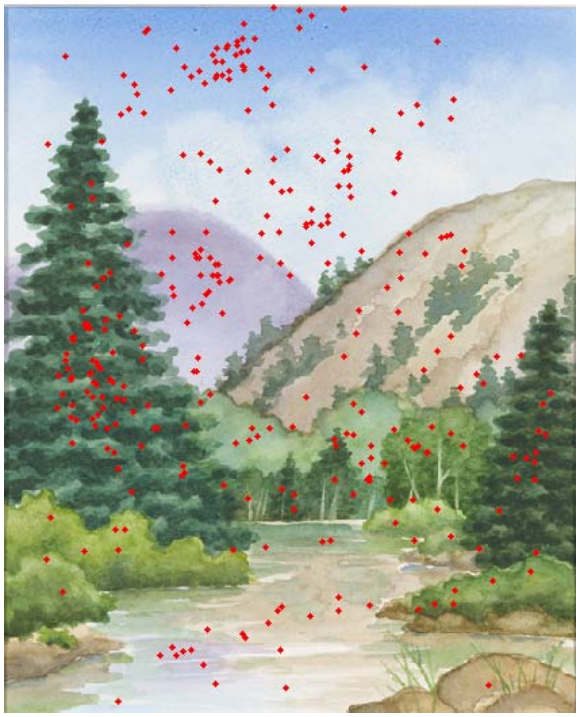
Computer graphics simulations of the touch-up problem in commercial painting, rendered from measured BRDF and texture data. The left image simulates the base and touch-up regions of a surface viewed from an angle of 15 degrees. The right image shows the surface viewed at an angle of 60 degrees. In this research, sponsored by the Sherwin-Williams Company, Suparna Kalghatgi, an M.S. student under the direction of Professor James Ferwerda, is using images like these to identify the causes of the touch-up problem and to develop solutions.



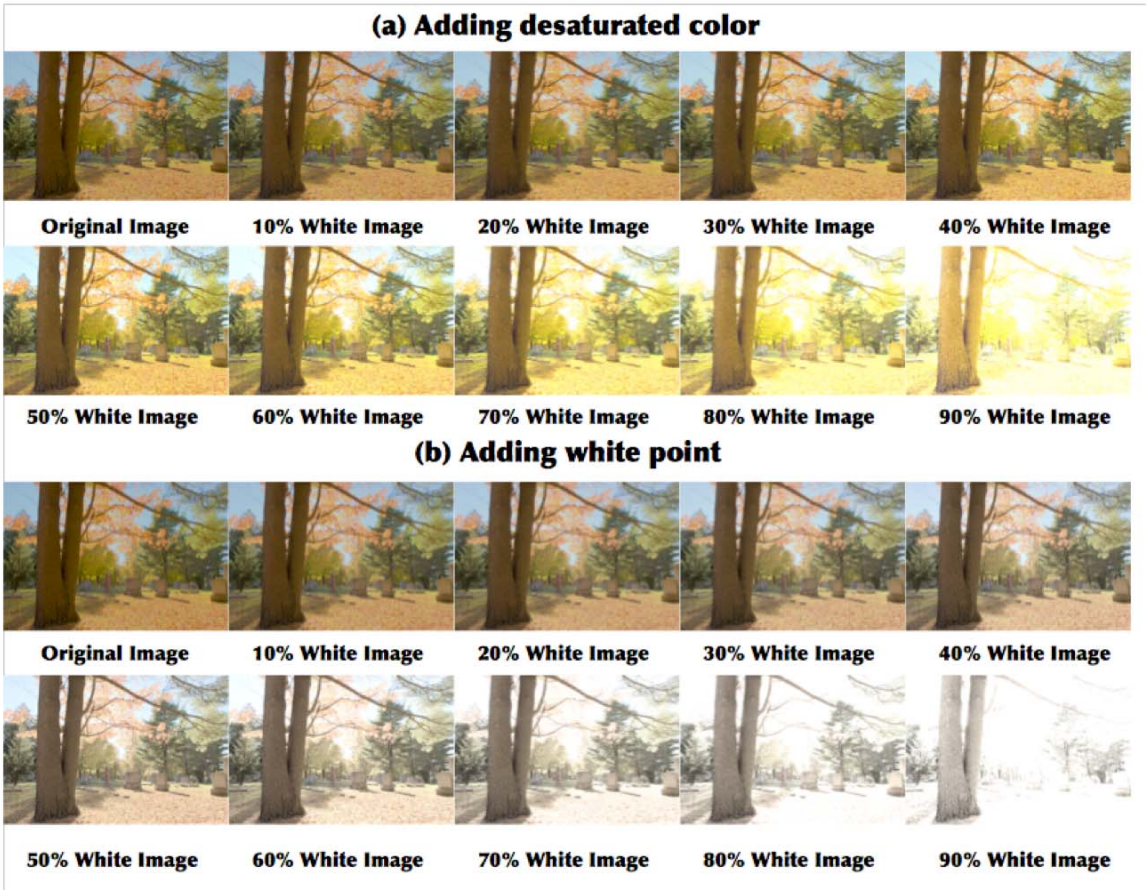
Luminance maps (left) of high dynamic range (HDR) and standard dynamic range (SDR) images of a computer graphics model. Note the high intensities in the HDR highlights and the highlight compression in the SDR image. (Right) Eye movement scanpaths over the images showing fixations made when discriminating surface gloss. In this research, sponsored in part by Eastman-Kodak, Jonathan Phillips, a Ph.D. student under the direction of Professor James Ferwerda, is investigating the role that specular highlight intensity plays in surface gloss perception.



David Long, Director of RIT's Motion Picture Science Program and a Color Science Ph.D. student, is working with Professor Mark Fairchild to explore the use of spectral imaging techniques in displays for digital cinema. Here, theoretically optimized display primaries for a 6-channel projector that minimizes observer metamerism are illustrated.



The red dots represent mouse clicks made by participants to indicate the region that most influenced their decision in a web-based experiment examining reproduction quality. This research is part of Jun (Chris) Jiang's dissertation research under the direction of Professor Fransizka Frey.



Two simulations of methods to increase display luminance. In (a) varying amounts of desaturated primaries are added to the display to examine the trade-off between primary saturation, brightness, and colorfulness. In (b) the addition of a white channel is simulated to investigate the same trade-offs. Color Science M.S. student Hao Li is working with Professor Mark Fairchild to psychophysically explore these perceptual trade-offs in display design.

M.S. student Dan Zhang and Professor James Ferwerda have developed a low-cost, color-calibrated HDR display that can be constructed from off-the-shelf components. This print-based HDR display incorporates an inkjet printer, a digital video projector, a digital camera, and a driving computer. Grayscale images from the projector are superimposed on color prints to create the HDR output. Custom software automatically calibrates and aligns the images. The current display has a peak luminance of ~2000 cd/m^2 and a dynamic range of ~20,000:1.

2010 Publications

Refereed Journal Articles

1. Berns, R.S., Designing white LED lighting for the display of art: A feasibility study, *Color Research and Application, in press* (2010)
2. Berns, R.S.; Hou, B., RIT-DuPont supra-threshold color-tolerance individual color-difference pair dataset, *Color Research and Application, in press* (2010)
3. Fairchild, M.D., Color appearance models and complex visual stimuli, *Journal of Dentistry, 38, s2, pp. e25-e33* (2010)
4. Johnson, G.M.; Song, X.; Montag, E.D.; Fairchild, M.D., Derivation of a color space for image color difference measurement, *Color Research and Application, 35, pp. 387-400* (2010)
5. Katayama, I.; Fairchild, M.D., Quantitative evaluation of perceived whiteness based on a color vision model, *Color Research and Application, 35, pp. 410-418* (2010)
6. Krivanek, J.J.; Ferwerda, J.A.; Bala, K.K., Effects of global illumination approximations on material appearance, *ACM Transactions on Graphics (SIGGRAPH)* (2010)
7. Kuang, J.; Heckaman, R.L.; Fairchild, M.D., Evaluation of HDR tone mapping algorithms using a high-dynamic-range display to emulate real scenes, *Journal of the Society of Information Display, 18, pp. 461-468* (2010)
8. Shen, S.; Berns, R.S., Color difference formula performance for several datasets of small color differences based on visual uncertainty, *Color Research and Application, in press* (2010)
9. Urban, P.; Berns, R.S., Paramer mismatch-based spectral gamut mapping, *IEEE Transactions on Image Processing, in press* (2010)

Conference Proceedings

10. Berns, R.S.; Haddock, M.I., A Color target for museum applications, *IS&T/SID, 18th Color Imaging Conference, San Antonio, Texas, United States, pp. 27-32* (2010)
11. Chen, P.; Fairchild, M.D.; Berns, R.S., Scaling lightness perception and differences above and below diffuse white, IS&T/SID, *18th Color Imaging Conference, San Antonio, Texas, United States, pp. 42-48 (*2010)
12 Darling, B.A.; Ferwerda, J.A., Tangible Display Systems: direct interfaces for computer-based studies of surface appearance, *Proceedings SPIE Electronic Imaging '10 (Human Vision and Electronic Imaging XV), SPIE, HVEI, 7257 0Z, San Jose, California, United States, pp. 1-12* (2010)
13. Derhak, M.W.; Berns, R.S., Comparing LabPQR and the spectral gamut mapping framework, *IS&T/SID, 18th Color Imaging Conference, San Antonio, Texas, United States, pp. 206-212* (2010)

Conference Proceedings, Continued

14. Fairchild, M.D., Still photography throwdown: Silver halide vs. silicon, *IS&T/SID, 18th Color Imaging Conference, San Antonio, Texas, United States* (2010)
15. Fairchild, M.D., Stimulating future color imaging scientists and engineers, *IS&T/SID, 18th Color Imaging Conference, San Antonio, Texas, United States, pp. 38-41* (2010)
16. Fairchild, M.D., The perceptibility of video artifacts: A perspective from color science, *VPQM, 5th International Workshop on Video Processing and Quality Metrics, 65, Scottsdale, Arizona, United States* (2010)
17. Fairchild, M.D.; Wyble, D.R., hdr-CIELAB and hdr-IPT: Simple Models for Describing the Color of High-Dynamic-Range and Wide-Color-Gamut Images, *IS&T/SID18th Color Imaging Conference, San Antonio, Texas, United States* (2010)
18. Ferwerda, J.A., The medium and the message: a revisionist view of image quality, *Proceedings SPIE Electronic Imaging '10 (Human Vision and Electronic Imaging XV), SPIE, HVEI, 7257 0J, San Jose, California, United States* (2010)
19. Ferwerda, J.A.; Kalghatgi S.; Darling, B.A., A psychophysical analysis of the touch-up problem, *IS&T/SID, 18th Color Imaging Conference, San Antonio, Texas, United States* (2010)
20. Ferwerda, J.A.; Selan, J.; Pellacini, F., Perception of lighting errors in image compositing, *IS&T/SID, 18th Color Imaging Conference, San Antonio, Texas, United States* (2010)
21. Gu, J.; Hitomi, Y.; Mitsunaga, T.; Nayar, S., Coded Rolling Shutter Photography: Flexible Space-Time Sampling, *IEEE Computer Society, IEEE International Conference on Computational Photography (ICCP), Boston, Massachusetts, United States, March* (2010)
22. Heckaman, R.L.; Berns, R.S., GO Colorants, *IS&T/SID, 18th Color Imaging Conference, San Antonio, Texas, United States, pp. 260-265* (2010)
23. Jiang, J.; Frey, F.; Farnand, S., Evaluating CATs as Predictors of Observer Adjustments in Softcopy Fine Art Reproduction. *IS&T/SID, 18th Color Imaging Conference, San Antonio, Texas, United States, pp. 54-61* (2010)
24. Phillips J.; Ferwerda, J.A.; Nunziata A., Gloss discrimination and eye movements, *Proceedings SPIE Electronic Imaging '10 (Human Vision and Electronic Imaging, SPIE, HVEI, 7257 0Z, San Jose, California, United States, pp. 1-12* (2010)
25. Zhang D.; Ferwerda, J.A., Appearance-based image splitting for HDR displays, *IS&T/SID, 18th Color Imaging Conference, San Antonio, Texas, United States* (2010)

Conference and Invited Presentations (No Proceedings)

26. Berns, R.S., Reconstructing the original colors of Vincent Van Gogh's The Bedroom, part of the permanent collection of the Van Gogh Museum, Amsterdam, Inter-Society Color Council Annual Meeting, Raleigh, North Carolina (2010)
27. Berns, R.S., Spectral Imaging, Getty Conservation Institute, Los Angeles, California (2010)
28. Berns, R.S., Turning back the ravages of time: Color reconstructions of Seurat and van Gogh paintings and drawings using color and imaging sciences, Getty Conservation Institute, Los Angeles, California (2010)

Conference and Invited Presentations (No Proceedings), Continued

29. Farnand, S.; Re-examining our Objective: Imaging, Accuracy, and Expectations, *Museum Computer Network conference in Austin, TX* (2010)
30. Ferwerda, J.A.; Phillips, Effects of image dynamic range on perceived surface gloss, *Vision Sciences Society, VSS 2010, Naples, Florida, United States* (2010)
31. Sisson, C.P.; Witwer, J.; Fairchild, M.D.; Pelz, J.B., Color variability analysis in fundus photography, 41st Annual Meeting and Educational Program, Ophthalmic Photographers' Society, Chicago (2010)
32. Zhang D.; Ferwerda, J.A., A low-cost, color-calibrated, reflective high dynamic range display, *Vision Sciences Society, VSS 2010, Naples, Florida, United States* (2010)

Technical Reports

33. Wyble, D.R.; Berns, R.S., Validating the Accuracy of the MCSL Imaging Goniospectrometer, *prepared for The Andrew W. Mellon Foundation, Rochester Institute of Technology, College of Science, Center for Imaging Science, Munsell Color Science Laboratory, Rochester, New York, United States, January* (2010)

Theses

34. Gu, J., Measurement, Modeling, and Synthesis of Time-Varying Appearance of Natural Phenomena, *Ph.D. Dissertation, Columbia University, Computer Science, New York, New York, United States, May* (2010)
35. Hou, B., Extending the RIT-DuPont Suprathreshold Data Set: Weighted Individual Discrimination Pair Data and New Chroma Dependency Visual Data, *M. S. Thesis, Rochester Institute of Technology Center for Imaging Science* (2010)

Munsell Color Science Laboratory Advisory Board

The MCSL Advisory Board is an advisory group composed of industrial and academic experts in color science and color aesthetics. Their role is to insure that the activities of MCSL are in concert with industrial needs, to evaluate the degree programs in Color Science, to promote funding opportunities, and to provide employment opportunities to Color Science and Imaging Science graduates focused on color-related problems.

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